

**Contribution to the knowledge of European Bourletiellidae (Collembola, Symphypleona). III.
Description of some species of *Heterosminthurus* and
Deuterosminthurus.**

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Contribution to the knowledge of European Bourletiellidae (Collembola, Symphypleona). III. Description of some species of *Heterosminthurus* and *Deuterosminthurus*. - According to our standard of the appendicular chaetotaxy, the following species are redescribed: *Heterosminthurus bilineatus* (Bourlet, 1842), *H. claviger* (Gisin, 1958), *H. insignis* (Reuter, 1876), *Deuterosminthurus bicinctus* (Koch, 1840), *D. flavus* (Gisin, 1946), *D. pallipes* (Bourlet, 1843), and *D. sulphureus* (Koch, 1840). Two new species are described: *Deuterosminthurus maculatus* sp. n. and *Deuterosminthurus pleuracanthus* sp. n. A discussion is given on the morphology of the claw, which is used to distinguish genera in the family Bourletiellidae. Appendicular chaetotaxic characters are relevant for defining genera, but more difficulty applicable for species distinctions. On the basis of such characters, apomorphies of *Heterosminthurus* and *Deuterosminthurus* are emphasized. Setae of body and color pattern are also used for species diagnoses, and a key to European species of *Deuterosminthurus* is provided.

Key-words: Collembola - Symphypleona - Bourletiellidae - *Heterosminthurus* - *Deuterosminthurus* - taxonomy - Europe.

INTRODUCTION

Ontogeny of the appendicular chaetotaxy in species of the genera *Heterosminthurus* and *Deuterosminthurus* is described according to a standard I proposed (NAYROLLES 1993a, 1993b) and since then have used to study the family Bourletiellidae (NAYROLLES 1994, 1995). Chaetotaxy of the body is less known, excepted for the trichobothrial pattern (RICHARDS 1968; BETSCH 1980; BETSCH & WALLER 1989) and the small abdomen. I recently discussed the setal nomenclature of the small

abdomen (NAYROLLES 1995). I deemed that the paper of BETSCH & WALLER (1994) is fundamental for any study to come. My view relied on two arguments: these authors observed all ontogenetic levels, and used a wide taxonomic range. Nevertheless, they did not propose a coherent nomenclature, probably because they considered further observations to be necessary. For a practical reason, I have adopted BRETTFELD' s (1990) nomenclature of the small abdomen, which is sufficient for the adult chaetotaxy. In the present paper, only the adult female circumanal setae are described. The female of *Heterosminthurus* and *Deuterosminthurus* has seven circumanal setae on the upper anal flap (the impaired a0 and the paired a1, a2, and a3), and five setae on the lower anal flap (from dorsal to ventral side: av1', av1, av2, av3, av4, and av5 = anal appendage). Two species redescribed here, *Heterosminthurus insignis* and *Deuterosminthurus bicinctus*, have already been studied by BRETTFELD (1990). I criticized this work (NAYROLLES 1993b), and explained the reasons for dismissing BRETTFELD' s nomenclature of appendicular setae.

I give a definition of each genus with emphasis on the most obvious apomorphies. Other characters will be discussed in a future paper. Nevertheless, an account of the empodial morphology is here needed.

According to BETSCH (1980), the empodial appendage of Bourletiellidae displays an array of regressive evolutions, so that the definition of genera is mainly based on its morphology. Using a scanning electron microscope, BETSCH & MASSOUD (1970) provided an accurate survey of this organ in *Jeannenotia stachi* Stach, 1956 (Sminthuridae). In the most typical form, the empodial appendage consists of a central rib, three lamellae, a subapical filament, and an apical needle. In comparison with the leg orientation, a lamella is external (thus opposite the claw), another is internal and slightly posterior, the last is anterior with a very slightly internal position. The central rib and a large area of lamellae are covered with granular cuticle. The ridge of lamellae is smooth, excepted for the basal part of the outer lamella. Smooth cuticle is also present on the tip of the empodial appendage, at the apex of the filament and needle. RICHARDS (1968) described the subapical filament as a projection of the central rib. BETSCH (1980) refuted Richards' view, showing that the subapical filament fitted with the outer lamella extension. More precisely, I consider that the ridge of the outer lamella extends beyond the central rib in the subapical filament, and the ridges of the other two lamellae join together into the apical needle.

European genera of Bourletiellidae can be readily defined by the shape of the empodial appendage. *Fasciosminthurus* Gisin, 1960 *sensu* Bretfeld, 1992 and the related genus *Cyprania* Bretfeld, 1992 — which perhaps should not have been isolated (NAYROLLES 1993b) — show an empodial appendage made up of a granular central rib ending in the filament and needle and devoid of lamellae. Filament and needle are thus the only traces of lamellae in these genera. In *Bourletiella* and *Casagnaudiella*, the lamellae, filament, and apical needle are reduced but distinct. Lamellae in *Deuterosminthurus* and *Heterosminthurus* are present, and they extend in a single apical spike. I was not able to state whether this apical point corresponds to the filament, the apical needle, or both welded together. BETSCH' s (1974) description of the pretarsus of *Bourletiellitas imerinensis* Betsch, 1974 and *Vatomadiella pauliani*

Betsch, 1974 shows that the apical spike likely amounts to the filament and apical needle welded together. It may be the same in *Deuterosminthurus* and *Heterosminthurus*. The use of scanning electron microscope would possibly permit us to resolve this problem.

All the species were collected in southwestern France and northeastern Spain. Abbreviations and setal symbol follow NAYROLLES (1993a, 1993b).

The material is deposited in the following institutions: Laboratoire d'Ecologie des Invertébrés Terrestres, Université Paul Sabatier, Toulouse, France (LEITT) — Muséum d'histoire naturelle de Genève, Switzerland (MHNG) — Muséum National d'Histoire Naturelle, Paris, France (MNHN) — Institute of Systematics and Population Biology (Zoologisch Museum) Universiteit van Amsterdam, the Netherlands (ZMA).

GENUS *Heterosminthurus* Stach, 1955

BRETFELD (1990) has noted the absence of Jp on all tibiotarsi of *H. insignis*. However, Ili is always more basal than Ja and Jp, and, in comparison with Ja, the apical remaining seta on the inner side of *H. insignis* is approximately at the same level regarding the longitudinal axis of legs. Therefore, I consider that Ili is absent and the remaining seta is Jp.

Heterosminthurus shows a characteristic pretarsus. The claw is devoid of tunica, pseudonychia and distinct teeth on the inner crest. The empodial lamellae of forelegs are reduced as well as the central rib which extends in a long apical point as a bent outward blade. On the mid and hindlegs, the central rib and lamellae are very distinct, and the apical point is shorter than on forelegs and bent toward inner side. The posterior pretarsal seta is absent as in all Bourletiellidae.

Heterosminthurus is characterized by the following apomorphies: empodium of forelegs different from the empodium of mid and hindlegs, (TI.)Ili absent, and setae (AT)a+2 and (AT)ai+2 present in adults.

Three species are studied: *H. insignis*, *H. bilineatus*, and *H. claviger*.

Heterosminthurus insignis (Reuter, 1876)

(Figs 1-8; Table I)

MATERIAL EXAMINED - FRANCE, dép. Lozère, district Nasbinals, Souvérols Lake, alt. 1230 m; peat bog, edge of lake on the floating vegetation, with *Menyanthes trifolia*, *Sphagnum* sp., *Drosera rotundifolia*, *Comarum palustre*, *Ligularia sibirica*, etc.; collected with a net on *Sphagnum* sp. and *D. rotundifolia* (LZ1d). 21-VI-1986: many specimens; 5 juv. mounted. 11-IX-1988: many specimens; 7 juv. and 7 ad. mounted (LEITT). — Dép. Gironde, district Carcans, between Carcans and Maubuisson, Hourtin-Carcans Lake, alt. 0 m; near the lake, with *Phragmites communis* and *Hydrocotyle vulgaris*; collected with a net on *Phragmites communis* (G14). 23-X-1987: 3 juv., 2 mounted (LEITT). — Dép. Pyrénées-Atlantiques, district Lecumberry, between Estérençuby and Larrau, near Astakieta wood, alt. 1150 m; small peat bog with *Sphagnum* sp., *Eriophorum* sp., *Vaccinium myrtillus* and *Erica vagans*; collected with a net on unselected plants (PA8a). 10-V-1987: 21 specimens; 1 juv. and 4 ad. mounted (LEITT).

DESCRIPTION

Development. — Number of juv. st. = 3.

Size ad. — ♂: 0.7 - 0.85 mm; ♀: 0.75 - 1.5 mm (female specimens collected in mountain do not reach beyond 1.2 mm).

Color. — Background yellow, often with ochre shades. Dark pigment sometimes present, particularly in the posterior area of great abd., the color being brown or wine-red in some specimens. A very dark male was collected, it was wholly black except between eyes, with pigment on legs and furcula. Antennae brown, eyepatches black. The different color-forms are similar to those described by BRETfeld (1988).

Great abd. — Back strongly concave. Trichobothria: A, B, and C in linear pattern. Dorsal setae: mesochaetae.

Antennae (figs 6 & 7). — Seta AIIe of ant. IV shifted toward apex. Antennal ratios: in ♀, ant. I : II : III : IV = 1 : 2.3 : 3.5 : 6.4 and ant. : ceph. diag. = 1.9; in ♂, ant. I : II : III : IV = 1 : 2.8 : 4.0 : 7.6 and ant. : ceph. diag. = 2.5. Chaetotaxic variables, in both sexes: $m(ISH^*) = 0.94$; in ♀ for G : $m = 97.6$ / $min = 91$ / $max = 102$; $m(RSh) = 0.55$; in ♂ for G : $m = 104.6$ / $min = 100$ / $max = 108$; $m(RSh) = 0.51$.

Head. — Eyes: 8+8; eyepatch with two setae. 2+2 ov. org. in the back-ventral area (see BRETfeld, 1990). Labral formula: 6/5-5-4. Cephalic setae: only mesochaetae in ♀; ♂ with 2+2 macrochaetae in inner edge of eyepatches. Several frontal setae small, but not broadened at the basis as in *H. bilineatus* and *H. claviger*.

Legs (figs 1-5). — Femur: cup present. Pretarsus characteristic of the genus.

Ventral tube. — Sacs warty from 2st st. on. Chaetotaxy: apical flaps with one pair of primary setae, corpus without seta.

Retinaculum. — At 1st st. rami tridentate, bidentate from 2nd. Chaetotaxy: on anterior lobe two setae appear at 3rd st. and one in ad.

Furcula (fig. 8). — Dental setae of Gpi, from Ipi to Vpi, are macrochaetae.

Small abd. — Made up of abd. V + abd. VI. Trichobothria: D and E. Male genital papilla with 16 setae. Size comparison of female circumanal setae: $av1' = av1 < av3 < av2 = av4$. An. app. spine-like, slightly bent. Ratio an. app. : mucro = 0.59.

Heterosminthurus bilineatus (Bourlet, 1842)

(Figs 9-15; Table II)

MATERIAL EXAMINED — FRANCE, dép. Aveyron, district Bessuéjols, Le Plateau de la Justice, alt. 450 m; meadow belonging to the phytosociological association of Orchido-Brometum with some small trees (*Quercus pubescens*, *Pinus sylvestris*, *Juniperus communis*) and *Bromus erectus*, *Hippocrepis comosa*, *Globularia vulgaris*, *Eryngium campestre*, etc.; collected with a net on unselected plants (AV1a). Several collections from March until December 1987. In all 62 specimens; 4 juv., 3 ♀, and 4 ♂ mounted (LEITT). — Dép. Aveyron, district La-Bastide-Solages, D33 road between Plaisance and Brasc, alt. 350 m; grass alongside a chestnut grove; collected with a net (AV15b). 22-VIII-1987: 77 specimens; 2 juv. and 2 ♂ mounted (LEITT). — Dép. Lozère, district Nasbinals, Souvérols Lake, alt. 1230 m; peaty soil near the lake, with *Eriophorum polystachyon*, *Equisetum limosum*, *Orchis incarnata*; collected with a net on unselected plants (LZ1c). 21-VI-1986: 114 specimens; 2 ♂ and 2 ♀ mounted. 19-VII-1986: 8 specimens. 11-IX-1988: 194 specimens; 5 juv. and 1 ♀ mounted (LEITT). — Dép.

Table II. Appendicular chaetotaxy of *Heterosminthurus bilineatus*

AP	Δ	—																																																																												
AD	Π	—																																																																												
		D: i0 T: i+1, a+1, e+1 Q: i-1, pe+1 Ai is a trichobothrium. In adult male: Ae, Aae, Aa, and e+1 are acanthoids; Be, Bae, Ba, Bai, and a+1 are small and slender.																																																																												
AT	Π	—																																																																												
	Δ	<table><tr><td></td><td>Ge</td><td>Gae</td><td>Ga</td><td>Gai</td><td>Gi</td><td>Gpi</td><td>Gp</td><td>Gpe</td></tr><tr><td>Setae -1</td><td>Q</td><td>T</td><td>Q</td><td>T</td><td>T</td><td>T</td><td>T</td><td>T</td></tr><tr><td>Setae 0</td><td>Q</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>T</td><td>D</td></tr><tr><td>Setae +1</td><td></td><td>T</td><td>T</td><td>Q</td><td>Q</td><td></td><td>Q</td><td>T</td></tr></table>									Ge	Gae	Ga	Gai	Gi	Gpi	Gp	Gpe	Setae -1	Q	T	Q	T	T	T	T	T	Setae 0	Q	D	D	D	D	D	T	D	Setae +1		T	T	Q	Q		Q	T	Other setae: Q: ae+2, a+2, ai+2, pe+2, pe+3 Only in adult male: Bae is an acanthoid; Ae, Aa, Ai, Ap, Be, Ba, Bai, Bi, and Bp are small and slender; p-1 is shifted toward inner side.																																
	Ge	Gae	Ga	Gai	Gi	Gpi	Gp	Gpe																																																																						
Setae -1	Q	T	Q	T	T	T	T	T																																																																						
Setae 0	Q	D	D	D	D	D	T	D																																																																						
Setae +1		T	T	Q	Q		Q	T																																																																						
AQ	Str	B completely zoned. Section M euwhorled with 5 whorls. Right euwhorlation. Subsegmentation formula: 1 + 6 + 1 = (A) + (M1, 5 + BA) + (BM+BB). Right subsegmentation.																																																																												
	A	Π	—																																																																											
	H	Allleae, Alllpe																																																																												
	Δ	Apical bulb: joined to the apex Subapical organ: small D: Alai Allpe is a blunt microchaeta Alle is shifted toward apex																																																																												
	M & B	H	Occurrences of H setae on M & B: for Heae 1-1-1-1-0.9/0.8, for Hipi 1-1-0-0-0/0, and for Hppe 1-1-1-1-1/0.3. m(h*) = 5.4.																																																																											
	G	Setae of BB: P: BBae, BBae, BBa, BBp, BBpe / all G setae on M are present. In female: BA complete whorl; n80%(BM) = 16-22; n80%(B) = 29-35; n80%(G) = 94-100. In male: BA complete whorl; n80%(BM) = 29-36; n80%(B) = 42-49; n80%(G) = 107-114. BBae and BBa are cucumiform setae on large base.																																																																												
SB	PS	—			—			—																																																																						
	Δ	P: 1 seta			P: 1 seta			P: 1 seta																																																																						
SA	Δ	—			P: 1 seta			P: 1 seta																																																																						
CX	Δ	P: i1			P: ae, i1, ms T: Oi1 Q: a			P: ae, i1, ms T: a, ai2, Oi1																																																																						
TR	Π	—			—			—																																																																						
	Δ	T: Oi1, Oi2			T: a2, Oi1, Oi2 Q: ae			T: a2, Oi1, Oi2 Q: ae																																																																						
FE	Π	—			—			pe1																																																																						
	Δ	delayed primordial seta: Q: ae3 T: pe2, Op Q: ai2, pe4			T: ai2, pe2, Op (T)Q: a5 (oc = 0.6) Q: pe4			T: a5, ai2, pe2 Q: ai3, ai4, pe4, Oi																																																																						
TI	V	lli			lli, lVp, Vp			lli, lllp, lVp, Vp																																																																						
	K	—			—			—																																																																						
	FP	+			+			+																																																																						
	Δ	T: 4ai1, Vai, Vpi, FSa, O2pe Q: 3a, 3p, 4a1, 4pi1, 4p1, 4ai2, FSai, FSpi lpi, lp and lpe are spatulate setae. Ja is a winged seta. Jp is a very slender microchaeta.			T: 4ai1, Vai, Vpi, FSa, O2pe Q: 3a, 3p, 4a1, 4pi1, 4ai2, FSai, FSpi (Q): 4p1 (oc = 0.7) lpi, lp and lpe are spatulate setae. Jp is a very slender microchaeta.			T: 3ai, 3i, 4ai1, 4i1, Vai, Vpi, FSa, O2pe Q: 2a, 3a, 3pi, 4a1, 4pi1, 4ai2, FSai, FSpi lp and lpe are spatulate setae.																																																																						
MA	Π	—																																																																												
	Δ	T: pe2, pe3																																																																												
DE	Δ	<table><tr><td></td><td>Ge</td><td>Gae</td><td>Ga</td><td>Gai</td><td>Gi</td><td>Gpi</td><td>Gp</td><td>Gpe</td></tr><tr><td rowspan="6">Whorls I to VI</td><td>I</td><td>P</td><td>P</td><td>P</td><td>P</td><td>P</td><td>P</td><td>P</td></tr><tr><td>II</td><td></td><td>P</td><td>P</td><td>P</td><td></td><td>P</td><td>P</td></tr><tr><td>III</td><td></td><td></td><td>P</td><td></td><td></td><td>P</td><td>P</td></tr><tr><td>IV</td><td></td><td></td><td>P</td><td></td><td></td><td>P</td><td>P</td></tr><tr><td>V</td><td></td><td></td><td></td><td></td><td></td><td>T</td><td>T</td></tr><tr><td>VI</td><td></td><td></td><td></td><td></td><td></td><td>Q</td><td>T</td></tr><tr><td>Whorl B</td><td>T</td><td></td><td>P</td><td></td><td></td><td>P</td><td>P</td><td>P</td></tr></table>									Ge	Gae	Ga	Gai	Gi	Gpi	Gp	Gpe	Whorls I to VI	I	P	P	P	P	P	P	P	II		P	P	P		P	P	III			P			P	P	IV			P			P	P	V						T	T	VI						Q	T	Whorl B	T		P			P	P	P	Other setae: P: 2pe	
	Ge	Gae	Ga	Gai	Gi	Gpi	Gp	Gpe																																																																						
Whorls I to VI	I	P	P	P	P	P	P	P																																																																						
	II		P	P	P		P	P																																																																						
	III			P			P	P																																																																						
	IV			P			P	P																																																																						
	V						T	T																																																																						
	VI						Q	T																																																																						
Whorl B	T		P			P	P	P																																																																						
MU	Δ	Chaetotaxy: — Morphology: anterior lamella simple, outer and inner lamellae smooth, mucro ending in a small point.																																																																												

Tarn, district Murat-sur-Vèbre, D162 road, Laouzas Lake, alt. 800 m; lakeside with *Balclutha arundinacea*, *Juncus silvaticus*, *Molinia caerulea*; collected with a net on unselected plants (TN3). 22-VIII-1987: 62 specimens; 3 ♂ mounted (LEITT). — Dép. Tarn, district Murat-sur-Vèbre, D162 road between Laouzas Lake and Murat-sur-Vèbre, about 3.5 km from Murat-sur-Vèbre, alt. 820 m; near a small stream in a damp meadow, with *Juncus* sp., *Glyceria* sp., and *Molinia caerulea*; collected with a net on unselected plants (TN4a). 22-VIII-1987: 77 specimens; 2 juv. mounted (LEITT).

DESCRIPTION

Development. — Number of juv. st. = 3.

Size ad. — ♂: 0.5 - 0.55 mm; ♀: 0.6 - 0.9 mm.

Color. — Background light yellow. Back of great abd. with a pair of longitudinal brown or orange stripes, generally quite diffuse, and joined behind. Several small patches on the posterior flanks of great abd. forming a pair of short stripes which do not reach halfway the body. A pair of posterior and lateral small elongated flecks is sometimes present. Trichobothrial sockets brown. Back of small abd. marbled with variable brown pigment. Head light with two small flecks behind eyes in the same line of great abd. streaks. Eyepatches black, antennae brown, legs very light yellow, and furcula white.

Great abd. — Back weakly concave. Trichobothria: A, B, and C in linear pattern. Dorsal setae: mesochaetae.

Antennae (figs 10-15). — Seta AIIe of ant. IV shifted toward apex. ♂ with several special-shaped setae on ant. II and III, and (AT)p-1 shifted toward inner side, so that it might almost be thought of as included in the generatrix Gpi. Antennal ratios: in ♀, ant. I : II : III : IV = 1 : 2.3 : 4.1 : 7.2 and ant. : cephalic diag. = 2.0; in ♂, ant. I : II : III : IV = 1 : 2.6 : 4.5 : 7.5 and ant. : cephalic diag. = 2.6. Chaetotaxic variables, in both sexes: $m(Ish^*) = 0.92$; in ♀ for G : $m = 97.3$ / $min = 90$ / $max = 101$; $m(RSh) = 0.53$; in ♂ for G : $m = 110.3$ / $min = 103$ / $max = 117$; $m(RSh) = 0.47$.

Head. — Eyes: 8+8; eyepatch with two setae. 1+1 ov. org. in the back-ventral area (it remains the ventral — anterior in arthropleon orientation — pair). Labral formula: 6/5-5-4. Cephalic setae: only mesochaetae in ♀; ♂ with several transformed setae. In dorsal part of the frons, near the sagittal plane, 2+2 acanthoids, the more posterior pair being the longer. Inner edge of eyes with 1+1 macrochaetae; frons with several small onion-shaped setae.

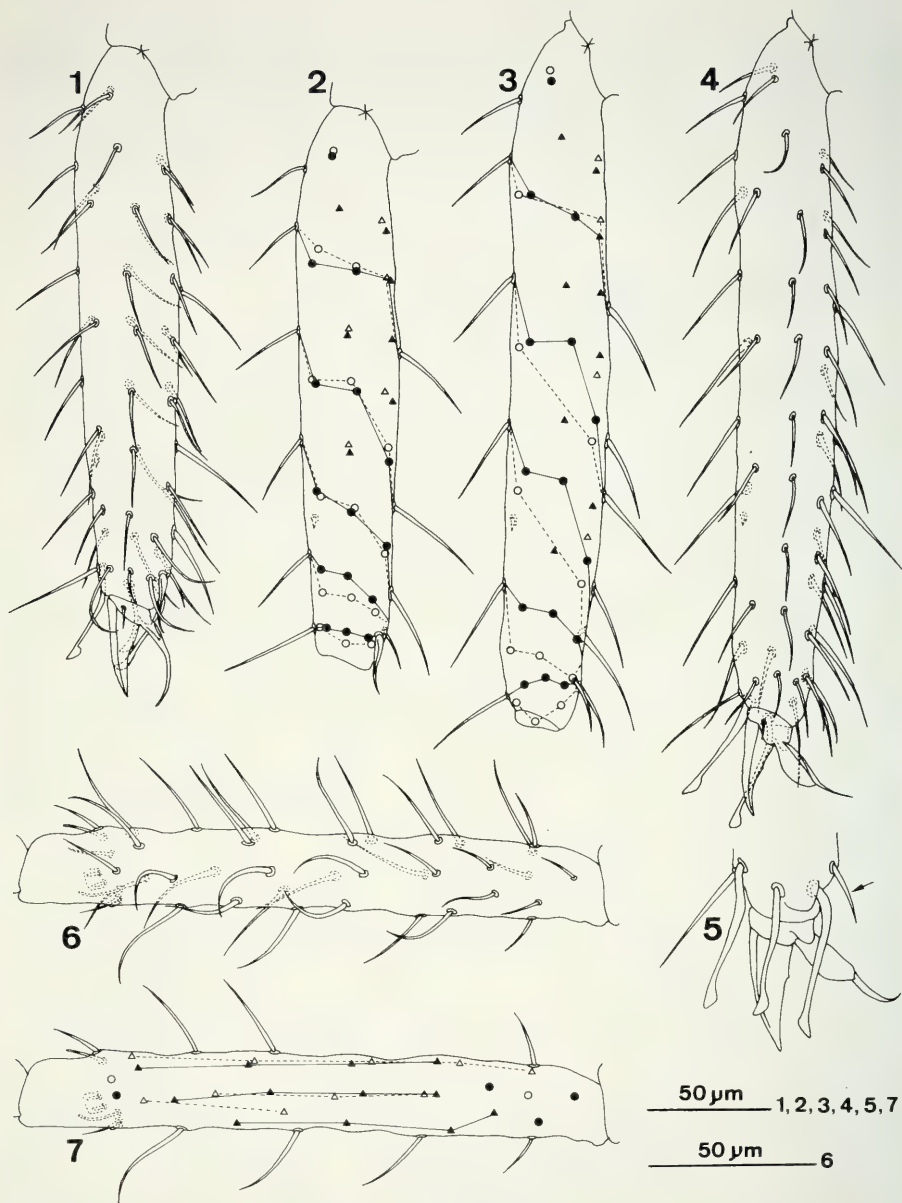
Legs (fig. 9). — Femur: cup present. (TI1,2)Jp is a very slender microchaeta. Pretarsus characteristic of the genus.

Ventral tube. — Sacs warty from 2st st. on. Chaetotaxy: apical flaps with one pair of primary setae, corpus without seta.

Retinaculum. — At 1st st. rami tridentate, bidentate from 2nd. Chaetotaxy: on anterior lobe two setae appear at 3rd st. and one in ad.

Furcula. — See chaetotaxic table.

Small abd. — Made up of abd. V + abd. VI. Trichobothria: D and E. Male genital papilla with 12 setae. Female circumanal seta av1' far shorter than the others, with the following size comparison: $av1' < av1 = av4 < av2 = av3$. An. app. spine-like, slightly bent. Ratio an. app. : mucro = 0.76.



FIGS 1-7

Heterosminthurus insignis ad.; 1: foretibiotsarsus, anterior view; 2: schematic representation of fig. 1, setae of Ge and Gi, and ov. org. are drawn, other setae are schematized as follows: a full symbol for a seta on reader's side (thus on anterior side), an empty symbol for a seta on opposite of reader's side, a circle for a primary seta, a triangle for a secondary seta; setae belonging to a same whorl are linked together by a line which is continuous on the anterior side and discontinuous on the posterior side; 3: schematic representation of fig. 4 (hindtibiotsarsus),

Heterosminthurus claviger (Gisin, 1958)

(Fig. 16)

MATERIAL EXAMINED — FRANCE, dép. Lot-et-Garonne, district Durance, track of Le Brocq farm, alt. 120 m; alongside a wood of *Pinus pinaster*, with *Calluna vulgaris* and *Ulex europæus*; collected with a net on unselected plants (LG2). 10-X-1989: many specimens; 8 juv. and 9 ad. mounted (LEITT). — Dép. Landes, district Brocas, Marais de la Coumme, alt. 80 m; near a wood, with *Molinia caerulea*, *Calluna vulgaris* and *Agrostis* sp.; collected with a net on unselected plants (LA6b). 22-X-1987: 38 specimens; 2 ♂ mounted. 10-X-1989: 43 specimens (LEITT).

DESCRIPTION

The 1st st. has not been observed, and the primary appendicular chaetotaxy is an interpretation based on comparisons with other instars of this species as well as the primary chaetotaxy of the other two studied species of *Heterosminthurus*.

Concerning the appendicular chaetotaxic table, refer to *H. bilineatus* (Table II), with the following differences:

Antennae. Sexual dimorphism: (AD)Be is an acanthoid in ♂, shape of other setae similar as in *bilineatus*, the acanthoids being slightly thicker — Occurrences of H setae on M & B: for Heae 1-1-1-1-1/0.8, and for Hppe 1-1-1-1-0.8/0.3. $m(h^*) = 5.5$ — Chaetotaxic variables in ♀ : $n80\%(BM) = 18-25$; $n80\%(B) = 31-38$; $n80\%(G) = 96-103$. In ♂ : $n80\%(BM) = 30-41$; $n80\%(B) = 43-54$; $n80\%(G) = 108-119$.

Legs. (FE2)a5 : ontogeny type T — (TI2)4p1 : ontogeny type Q.

Development. — Number of juv. st. = 3.

Size ad. — ♂: 0.55 - 0.6 mm; ♀: 0.65 - 0.9 mm.

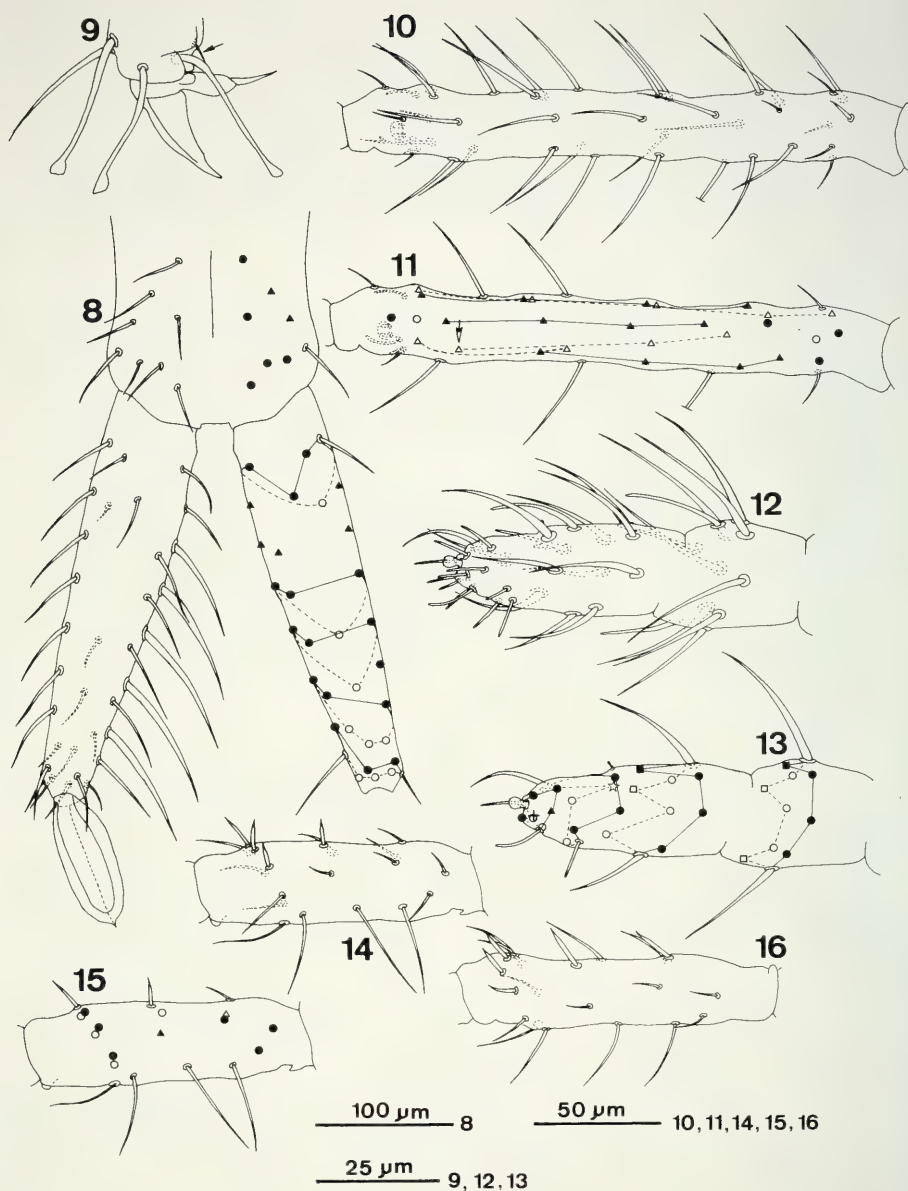
Color. — Same pattern as in *H. bilineatus* with a darker pigment (dark brown).

Great abd. — Back weakly concave in posterior area. Trichobothria: A, B, and C in linear pattern. Dorsal setae: mesochaetae.

Antennae (fig. 16). — Seta AIIe of ant. IV shifted toward apex. ♂ with several special-shaped setae on ant. II and III, and (AT)p-1 shifted toward inner side, so that it might almost be thought of as included in generatrix Gpi. Antennal ratios: in ♀, ant. I : II : III : IV = 1 : 2.2 : 3.7 : 6.6 and ant. : ceph. diag. = 2.0; in ♂, ant. I : II : III : IV = 1 : 2.3 : 4.2 : 6.7 and ant. : ceph. diag. = 2.7. Chaetotaxic variables, in both sexes: $m(ISH^*) = 0.91$; in ♀ : for *G*: $m = 98.2$ / $min = 94$ / $max = 103$; $m(RSh) = 0.53$; in ♂ : for *G*: $m = 113.6$ / $min = 105$ / $max = 120$; $m(RSh) = 0.45$.

Head. — Eyes: 8+8; eyepatch with two setae. 1+1 ov. org. in the back-ventral area (it remains the ventral pair). Labral formula: 6/5-5-4. Cephalic setae: only mesochaetae in ♀ ; ♂ with several transformed setae. In dorsal part of the frons, near

same legend as in fig. 2; 4: hindtibiotsarsus, anterior view; 5: apex of midleg, detail in posterior view, the arrow points the seta Jp, Ipi has its socket topped by an integumentary bulge; 6: ant. III, anterior view; 7: schematic representation of fig. 6, setae of Ge and Gi are drawn as those of antennal III organ (Xe, Xi) and its guard setae (Aai, Api, Ape), other setae are schematized as follows: a full symbol for a seta on reader's side (thus on anterior side), an empty symbol for a seta on opposite of reader's side, a circle for a primary seta, a triangle for a secondary seta; secondary setae belonging to a same generatrix are linked together by a line which is continuous on the anterior side and discontinuous on the posterior side.



FIGS 8-16

Fig. 8: *Heterosminthurus insignis* ad., furcula, posterior view; on the right, schematic representation as follows: setae of Ge and Gi drawn, a full symbol for a seta on reader's side (thus on posterior side), an empty symbol for a seta on opposite of reader's side, a circle for a primary seta, a triangle for a secondary seta; for the dental whorls I to IV and B, setae belonging to a same whorl are linked together by a line which is continuous on the posterior side and discontinuous on the anterior side. Figs 9-15: *Heterosminthurus bilineatus* ♂; 9: apex

the sagittal plane, 2+2 acanthoids, the more posterior pair being thick, very long, and widened at apex as fan-shaped. Inner edge of eyes with several fairly long setae; frons with several small onion-shaped setae.

Legs. — Femur: cup present. (TI1,2)Jp is a very slender microchaeta. Pretarsus characteristic of the genus.

Ventral tube. — Sacs warty from 2st st. on. Chaetotaxy: apical flaps with one pair of primary setae, corpus without seta.

Retinaculum. — Rami bidentate from 2nd st. on. Chaetotaxy: on anterior lobe two setae appear at 3rd st. and one in ad.

Furcula. — Same chaetotaxy as in *bilineatus*.

Small abd. — Made up of abd. V + abd. VI. Trichobothria: D and E. Male genital papilla with 12 setae. Size comparison of female circumanal setae: $av1' < av1 < av2 = av3 = av4$. An. app. spine-like, slightly bent. Ratio an. app. : mucro = 0.71.

DISCUSSION

On the criterion of presence vs absence of setae, the appendicular chaetotaxy is virtually the same among the three species. Indeed, few setae variable in a species and constant in others are the only differences. Such characters, perhaps variable between populations, cannot be used to distinguish species. Setal shape provides some relevant characters, e.g., the dental macrochaetae in *insignis*, and (TI1,2)Jp as a minute microchaeta in *bilineatus* and *claviger*. Morphology of cephalic setae makes the distinction between males of *claviger* and *bilineatus* easy. Juveniles and females can be identified by the lateral chaetotaxic pattern of great abd. described by BRETFELD (1986).

Genus *Deuterosminthurus* (Börner, 1901) *sensu* Gisin, 1960

Deuterosminthurus, as other genera of Bourletiellidae, displays a particular pretarsal morphology. The claw is without tunica and pseudonychia, and its inner crest bears a small and sometimes hardly distinguishable tooth. The empodium is ending in a single apical spike. The reduction of empodial lamellae in all legs is an apomorphy of *Deuterosminthurus*. The absence of the femoral setae (FE3)ai3 and (FE3)ai4 in all the species of *Deuterosminthurus* I have observed also fits with a

of midleg, detail in posterior view, the arrow points the microchaeta Jp, the sockets of Jp and Ipi are hidden by an integumentary fold; 10: ant. III, anterior view; 11: schematic representation of fig. 10, same legend as in fig. 7, the arrow shows the displacement of the seta p-1; 12: apex of ant. IV (with the section A and the whorl M1), anterior view; 13: schematic representation of fig. 12, setae of Ge and Gi drawn, other setae are schematized as follows: a full symbol for a seta on reader's side (thus on anterior side), an empty symbol for a seta on opposite reader's side, a square for a H seta, a triangle for the secondary seta (AIai), and a circle for a primary G seta except a cross for AA and a star for AIIpe; setae belonging to a same whorl are linked together by a line which is continuous on the anterior side and discontinuous on the posterior side; 14: ant. II, anterior view; 15: schematic representation of fig. 14, setae of Ge and Gi are drawn, other setae are schematized as follows: a full symbol for a seta on reader's side (thus on anterior side), an empty symbol for a seta on opposite of reader's side, a circle for a primary seta, a triangle for a secondary seta. Fig. 16: *Heterosminthurus claviger* ♂, ant. II, anterior view.

putative evolved character. The same assumption can be made for the absence of (DE)IIae and (DE)IVa.

From observations on an extensive material, I state that the character "strong vs weak tooth on the inner lamella of claw", which has been frequently mentioned in literature, is worthless. This point and chaetotaxy involve to consider that the species, subspecies, or forms described as *pallipes*, *repandus*, *mixtus*, *feneyssi*, and *beckeri* (see ELLIS 1974) merely amount to only one species: *D. pallipes*. All these forms chiefly corresponded to differences in color patterns, but color is a variable character and a large range of tinges can be observed. ELLIS (1974) clustered these forms in two species, *repandus* and *pallipes*, and in 1978 he questioned the separation of both. The name *pallipes* (Bourlet, 1843), coined for a dark form, is prior to *repandus* (Ågren, 1903). The valid name is thus *pallipes*; even though the form *pallipes*, in its original description, relates to a rare color-form (males and females dark blue-purple excepted for mouth, furcula, and legs) observed for some specimens collected in Atlantic meadows, and the name *repandus* is more frequently cited in literature than *pallipes*.

The different color-forms of *pallipes* do not present a defined pattern. On the other hand, *D. maculatus* sp. n., a close species to *pallipes*, has a constant color pattern which consists of sharply outlined maculae always laid down in the same arrangement. In some places, both species occurred together, and never it was found a specimen with an intermediate color; such a fact involved to give each form a specific status. Hence, I tried in vain to find a chaetotaxic trait which would have permitted to distinguish these species. I observed that all specimens of *pallipes* collected from Département Aveyron bear six long setae on the most posterior cross row of great abd. whilst all other species have four, and, for a while, I believed that this setal number was a worthwhile character. Nevertheless, I collected specimens of *pallipes* from Atlantic populations with four setae, and in intermediate locations with four to six. Another character lies in the thickness of male antennal acanthoids, but the difference is not very strong, and this character does not provide a sharp distinction between both species.

Distinction between *D. bicinctus* and *D. flavus* raised another problem. Typical two black spotted specimens and others uniformly light yellow occurred together in several populations of *bicinctus*. This last form absolutely looked like *flavus*, so that one could question the specific status of *flavus*. Nevertheless, I uncovered a chaetotaxic difference on the fourth antennal segment which permits to maintain the distinction between *bicinctus* and *flavus*. The number of setae of the intergeneratrices Heae and Hppe, and limited to the section M, is seven in *flavus* and nine in *bicinctus*. For these setae, I observed a compensation phenomenon* in *flavus*, so that a sharp distinction

* Variable setae may present relationships for their presence vs absence, i. e., statistically speaking, they are correlated (NAYROLLES 1991a). For a set of correlated setae, histogram of the variable "observed number of setae" is compared with the theoretical histogram related to the assumption of independence between setae. In the phenomenon of compensation (NAYROLLES 1993c), the observed histogram is much narrower than the calculated one. Consequently, characters, i. e. features near constant within and variable between species, should refer not to individual setae but to sets of correlated setae. In this case, variables are setal numbers.

between the species cannot be performed by considering the setae one by one but by calculating a setal number. Another difference lies in the instar of appearance of the seta (FE2)a5, in third instar in *flavus* and in adult in *bicinctus*, and (AD)a+1, in adult in *flavus* and in third instar in *bicinctus*.

ELLIS (1974) described *Deuterosminthurus sulphureus mediterraneus*, and justified this subspecies arguing that the male did not bear the two posterior acanthoids on the upper anal flap, so conspicuous in the typical form. I deem this character is sufficient for raising the subspecies to specific rank: *Deuterosminthurus mediterraneus* Ellis, 1974, stat. nov. Furthermore, the ecological analysis of epigeic Symphyleona (NAYROLLES 1991b) showed that *D. sulphureus* scarcely occurred in Mediterranean areas; it was only collected in submediterranean zone, and in stations where the drought was temperate by local conditions as waterside or undergrowth. On the other hand, *D. mediterraneus* is likely a true Mediterranean species since ELLIS (1974) collected it in Rhodos Island (Greece).

Deuterosminthurus pleuracanthus sp. n.

(Figs 17-20; Table III)

MATERIAL EXAMINED - SPAIN, prov. Huesca, Puerto de Monrepós, alt. 1260 m; pasture and rest area of cattle, with many graminæ, *Poa* sp., *Phleum* sp., *Alopecurus pratensis*, *Dactylis glomerata*, and also *Achillea millefolium*, *Daucus carota*; collected with a net on these plants (HU24a). 21-VI-1990. Syntypes: 59 specimens; 13 juv., 3 ♂, and 5 ♀ mounted (8 specimens in alcohol in MHNG, 8 in MNHN, 8 in ZMA, other specimens in LEITT).

Other material.— Same station. 1-VIII-1987: 5 ♀ and 1 ♂; 1 ♀ and 1 ♂ mounted. 30-V-1990: 1 ♀ mounted (LEITT).

DESCRIPTION

Development. — Number of juv. st. = 3.

Size ad. — ♂: 0.45 - 0.55 mm; ♀: 0.6 - 0.85 mm.

Color. — Light yellow, slightly pigmented with orange in posterior area of great abd. Head light with a small orange fleck on the frontal ocellus. Antennae light brown-yellow; eyepatches black. Legs very light yellow; furcula white.

Great abd (figs 17 & 18). — Back concave in posterior area. Trichobothria: A, B, and C in linear pattern. Dorsal setae different between sexes: female with normal mesochaetae, and male with several swollen and spine-like setae (acanthoids).

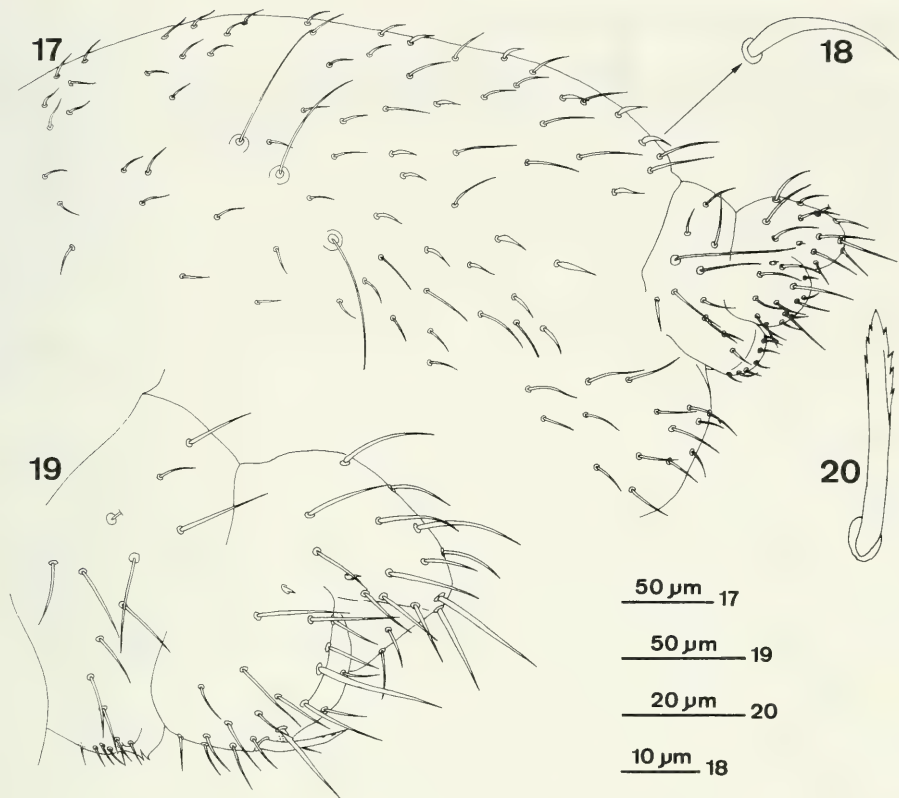
Antennae. — Antennal ratios: in ♀, ant. I : II : III : IV = 1 : 2.0 : 3.1 : 5.5 and ant. : ceph. diag. = 1.7 ; in ♂, ant. I : II : III : IV = 1 : 2.0 : 3.3 : 6.3 and ant. : ceph. diag. = 2.1. Chaetotaxic variables, in both sexes: $m(ISH^*) = 0.66$; in ♀ : for G : $m = 90.8 / \min = 87 / \max = 95$; $m(RSh) = 0.44$; in ♂ : for G : $m = 102.3 / \min = 98 / \max = 106$; $m(RSh) = 0.39$.

Head. — Eyes: 8+8; eyepatch with two setae. Cephalic setae: mesochaetae. No ov. org. Labral formula: 6/5-5-4.

Legs. — Femur: cup present. Tibiotarsal generatrix Gp without secondary seta. Pretarsus characteristic of the genus.

Ventral tube. — Sacs warty from 2st st. on. Chaetotaxy: apical flaps with one pair of primary setae, corpus without seta.

MA	II	—									
	Δ	T: pe2, pe3									
DE	Δ	Other setae: P: 2pe									
			Ge	Gae	Ga	Gai	Gi	Gpi	Gp	Gpe	
		Whorls I to VI	I	P	P	P	P	P	P	P	
			II			P			P	P	P
			III			P			P	P	P
			IV						P	P	P
			V						T	T	T
			VI						Q		T
		Whorl B		T		P			P	P	P
MU	Δ	Chaetotaxy: — Morphology: anterior lamella simple, outer and inner lamellae smooth.									



FIGS 17-20

Deuterostminthurus pleuracanthus sp. n.; 17: ♂, small abd. and lateral and dorsal area of great abd., lateral view; 18: detail of a swollen seta of great abd.; 19: ♀, small abd. in lateral view; 20: right an. app. in ventral view.

Retinaculum. — At 1st st. rami tridentate, bidentate from 2nd. Chaetotaxy: on anterior lobe two setae appear at 3rd st. and one in ad.

Furcula. — See chaetotaxic table.

Small abd. (figs 19-20). — Made up of abd. V + abd. VI. Trichobothria: D and E. Male genital papilla with 12 setae. Female circumanal setae av1' and av1 shorter than the others. An. app. fairly long, flat, and with few serration at apex. Ratio an. app. : mucro = 0.64.

DISCUSSION

The acanthoids of male great abd. permit to distinguish *D. pleuracanthus* from all other species of *Deuterostminthurus*.

Etymology: The name *pleuracanthus*, from Greek *pleuron* = flank and *acantha* = spine, refers to the acanthoids on the male great abd.

Deuterosminthurus bicinctus (Koch, 1840)

MATERIAL EXAMINED - FRANCE, dép. Gers, district Cravencères, between Cravencères and Manciet, alt. 150 m; undergrowth of *Quercus robur*; collected with a net (GS1). 5-V-1990: 189 specimens; 6 juv., 2 ♀, and 1 ♂ mounted (20 specimens in alcohol in MHNG, 20 in MNHN, 20 in ZMA, other specimens in LEITT). — Dép. Tarn, district Rouairoux, between Lacabarède and Rouairoux, about 1-2 km from Lacabarède, alt. 440 m; grove with chestnut, *Quercus pubescens*, and *Acer pseudo-platanus*, in undergrowth: *Lonicera periclymenum*, *Teucrium scorodonia*, *Pteridium aquilinum*, *Euphorbia silvatica*, *Lamium hybridum*, *Rubus* sp., etc.; collected with a net on unselected plants (TN1). 22-VIII-1987: 66 specimens; 4 ♂ and 4 ♀ mounted (LEITT). — SPAIN, prov. Guipúzcoa, between Bergara and Zumarraga, near Puerto de Descarga, alt. 550 m; damp grove with *Alnus glutinosa*, *Fraxinus excelsior*, *Sorbus torminalis*, *Corylus avellana*, in undergrowth: *Athyrium filix-femina*, *Geranium robertianum*, etc. (phytosociological association of Alno Ulmion); collected with a net on unselected plants (PB1): 36 specimens; 5 juv. mounted (LEITT).

DESCRIPTION

Concerning the appendicular chaetotaxic table, refer to *D. pleuracanthus* (Table III), with the following differences:

Antennae. (AD)a+1 ontogeny type T — Occurrences of H setae on M & B: for Heae 1-1-1-1-0/0, and for Hppe 1-1-1-1-1/0.2. $m(h^*) = 4.6$ — Chaetotaxic variables in ♀: $n80\%(BM) = 13-16$; $n80\%(B) = 26-29$; $n80\%(G) = 91-94$. In ♂: $n80\%(BM) = 18-25$; $n80\%(B) = 31-38$; $n80\%(G) = 96-103$. BA complete whorl in both sexes.

Legs. (FE2)a5 ontogeny type Q.

Furcula. (MA)pe2 ontogeny type T(Q), $oc = 0.8$.

Development. — Number of juv. st. = 3.

Size ad. — ♂: 0.5 - 0.55 mm; ♀: 0.5 - 0.75 mm.

Color. — Background yellow with, in the normal form, two, one before, one behind, black flecks on great abd. The anterior spot is the larger. Head dotted with two small spots behind eyes. In some cases, I found other colored specimens living with this typical form in a same population. Some had many minute black spots in place of the black flecks, these minute spots were orange-pink in others, the lightest form was pigmented with orange, particularly in the rear of great abd., and without a trace of the typical flecks. In all cases, antennae orange-brown, eyepatches black, legs and furcula light.

Great abd. — Back concave in posterior area. Trichobothria: A, B, and C in linear pattern. Dorsal setae: mesochaetae.

Antennae. — Antennal ratios: in ♀, ant. I : II : III : IV = 1 : 1.8 : 3.0 : 5.6 and ant. : cephalic diag. = 1.6; in ♂, ant. I : II : III : IV = 1 : 1.9 : 3.2 : 5.6 and ant. : cephalic diag. = 2.1. Chaetotaxic variables, in both sexes: $m(ISH^*) = 0.77$; in ♀: for G: $m = 92.6$ / $min = 90$ / $max = 95$; $m(RSh) = 0.48$; in ♂: for G: $m = 99.3$ / $min = 95$ / $max = 106$; $m(RSh) = 0.45$.

Head. — Eyes: 8+8; eyepatch with two setae. Cephalic setae: mesochaetae. No ov. org. Labral formula: 6/5-5-4.

Legs. — Femur: cup present. Tibiotarsal generatrix Gp without secondary seta. Pretarsus characteristic of the genus.

Ventral tube. — Sacs warty from 2st st. on. Chaetotaxy: apical flaps with one pair of primary setae, corpus without seta.

Retinaculum. — At 1st st. rami tridentate, bidentate from 2nd. Chaetotaxy: on anterior lobe two setae appear at 3rd st. and one in ad.

Furcula. — Same chaetotaxy as in *pleuracanthus* (excepted for a manubrial variable seta).

Small abd. — Made up of abd. V + abd. VI. Trichobothria: D and E. Male genital papilla with 12 setae. Female circumanal setae with about the same length. An. app. fairly long, flat, and serrated. Ratio an. app. : mucro = 0.61.

Deuterosminthurus flavus (Gisin, 1946)

MATERIAL EXAMINED — SPAIN, prov. Vizcaya, between Elgoibar and Markina-Xemein, alt. 350 m; undergrowth of *Pinus pinaster*, with *Athyrium filix-femina*, *Holcus lanatus*, etc.; collected with a net on unselected plants (PB2). 9-VII-1987: 106 specimens; 7 juv. and 9 ad. mounted (12 specimens in alcohol in MHNG, 12 in MNHN, 12 in ZMA, other specimens in LEITT). — Prov. Vizcaya, between Ondanoa and Lekeitio, alt. 100 m; moor with *Pteridium aquilinum*, *Brachypodium pinnatum*, *Agrostis setacea*, *Lithospermum prostratum*, *Androsæum officinale*, *Molinia caerulea*, etc.; collected with a net on unselected plants (PB3). 9-VII-1987: 34 specimens; 2 ♂ mounted (LEITT). — Prov. Vizcaya, between Bermeo and Bakio, near Cabo Machichaco, alt. 70 m; undergrowth of *Pinus pinaster* with *Pteridium aquilinum*, *Hedera helix*, *Viburnum tinus*, *Smilax aspera*; collected with a net (PB19). 16-IX-1987: 7 specimens; 1 ♂ and 1 ♀ mounted (LEITT).

DESCRIPTION

Concerning the appendicular chaetotaxic table, refer to *D. pleuracanthus* (Table III), with the following differences:

Antennae. (AD)a+1 ontogeny type Q — Occurrences of H setae on M & B: for Heae 1-1-0.9-0.2-0/0, and for Hppe 1-1-1-0.8-0.2/0. $m(h^*) = 3.6$ — Chaetotaxic variables in ♀: $n80\%(BM) = 11-15$; $n80\%(B) = 24-27$; $n80\%(G) = 89-92$. In ♂: $n80\%(BM) = 17-21$; $n80\%(B) = 30-34$; $n80\%(G) = 95-99$. BA complete whorl in ♂, with variable setae in ♀.

Legs. (TI1)3p ontogeny type (Q), oc = 0.3 — (TI1)4p1 ontogeny type (Q), oc = 0.7.

Development. — Number of juv. st. = 3.

Size ad. — ♂: 0.45 - 0.5 mm; ♀: 0.55 - 0.85 mm.

Color. — Background yellow with orange on the back of great abd. Head more or less pigmented, with a small orange fleck on the frontal ocellus. Antennae light brown-yellow; eyepatches black, legs very light, and furcula white.

Great abd. — Back concave in posterior area. Trichobothria: A, B, and C in linear pattern. Dorsal setae: mesochaetae.

Antennae. — Antennal ratios: in ♀, ant. I : II : III : IV = 1 : 1.9 : 2.9 : 5.5 and ant. : cephalic diag. = 1.6; in ♂, ant. I : II : III : IV = 1 : 1.9 : 3.3 : 6.5 and ant. : cephalic diag. = 2.1. Chaetotaxic variables, in both sexes: $m(ISH^*) = 0.59$; in ♀: for G: $m = 90.2 / \min = 87 / \max = 93$; $m(RSh) = 0.40$; in ♂: for G: $m = 97.0 / \min = 94 / \max = 100$; $m(RSh) = 0.38$.

Head. — Eyes: 8+8; eyepatch with two setae. Cephalic setae: mesochaetae. No ov. org. Labral formula: 6/5-5-4.

Legs. — Femur: cup present. The generatrix Gp of forelegs often bears a seta which is either 3p or 4p1. No seta on Gp of mid and hindlegs. Pretarsus characteristic of the genus.

Ventral tube. — Sacs warty from 2st st. on. Chaetotaxy: apical flaps with one pair of primary setae, corpus without seta.

Retinaculum. — At 1st st. rami tridentate, bidentate from 2nd. Chaetotaxy: on anterior lobe two setae appear at 3rd st. and one in ad.

Furcula. — Same chaetotaxy as in *pleuracanthus*.

Small abd. — Made up of abd. V + abd. VI. Trichobothria: D and E. Male genital papilla with 12 setae. Female circumanal setae with about the same length. An. app. fairly long, flat, pointed and serrated. Ratio an. app. : mucro = 0.52.

Deuterosminthurus sulphureus (Koch, 1840)

MATERIAL EXAMINED — FRANCE, dép. Aveyron, district Bessuéjols, Le Plateau de la Justice, alt. 450 m; meadow of the phytosociological association of Orchido-Brometum with some small trees (*Quercus pubescens*, *Pinus sylvestris*, *Juniperus communis*) and *Bromus erectus*, *Hippocrepis comosa*, *Globularia vulgaris*, *Eryngium campestre*, etc.; collected with a net on unselected plants (AV1a). Several collections from 17-IV-1987 until 13-VI-1987. In all 55 specimens; 13 juv. mounted (LEITT). — Dép. Aveyron, district Montrozier, Causse Comtal, road to Gages, alt. 620 m; grass on limestone with *Bromus erectus*, *Kaeria valesiaca*, *Festuca gr. ovina*, *Coronilla minima*, *Hippocrepis comosa*, *Lotus corniculatus*, *Anthyllis vulneraria*, *Carduncellus mitissimus*, *Eryngium campestre*, *Teucrium chamædrys*, etc.; collected with a net on unselected plants (AV2a). Several collections from 17-IV-1987 to 30-VII-1987. Many specimens; 6 ad. and many juv. mounted (LEITT). — Dép. Haute-Garonne, district Toulouse, campus of Université P. Sabatier, alt. 160 m; long grass under fruit trees; collected with a net. 21-V-1988: many specimens collected and mounted (LEITT). — Dép. Ariège, district Ormolac-Ussat-les-Bains, Ariège river bank, alt. 500 m; long grass with many gramineae and *Rhinanthus major*, *Anthyllis vulneraria*, *Orchis militaris*, etc.; collected with a net on unselected plants (AR2a). 22-V-1987: many specimens; 1 juv. and 4 ad. mounted (LEITT).

DESCRIPTION

Concerning the appendicular chaetotaxic table, refer to *D. pleuracanthus* (Table III), with the following differences:

Antennae. I have noted differences between two studied populations, particularly for the number of setae in males. (AD)a+1 ontogeny type T — (AD)pe+1 ontogeny type (T)Q or Q depending on populations — Occurrences of H setae on M & B: for Heae 1-1-1-1-0/0, and slightly variable for Hppe, 1-1-0.8-0.3-0/0 or 1-1-1-0-0/0, depending on populations. In all cases, $m(h^*) = 3.5$ — Chaetotaxic variables in ♀: $n80\%(BM) = 10-15$; $n80\%(B) = 23-28$; $n80\%(G) = 88-93$. ♂ with differences between populations: $n80\%(BM) = 20-25$ / $24-30$; $n80\%(B) = 33-38$ / $37-43$; $n80\%(G) = 98-103$ / $102-108$. BA complete whorl in both sexes.

Legs. (TI1)3p ontogeny type Q — (TI1)4p1 ontogeny type Q — (TI2)3p ontogeny type (Q), oc = 0.7 — (TI2)4p1 ontogeny type (Q), oc = 0.2 — Setae of the

outer side of tibiotarsi, (TI.)IIIe, (TI.)IIIae, (TI.)IIIpe, (TI.)IVe, (TI.)IVae, (TI.)IVpe, (TI1,2)Ve, (TI1,2)Vae, (TI1,2)Vpe, (TI3)IIe, are macrochaetae, their length grows during development.

Furcula. The primary seta (DE)IVpi is generally present, but may be variable in some populations.

Development. — Number of juv. st. = 3.

Size ad. — ♂: 0.55 - 0.6 mm; ♀: 0.7 - 1.0 mm.

Color. — Golden yellow with more orange in males. A small orange fleck on the frontal ocellus. Eyepatches black, antennae light yellow, legs very pale yellow, furcula white.

Great abd. — Back concave in posterior area. Trichobothria: A, B, and C in linear pattern. Dorsal setae: mesochaetae.

Antennae. — Antennal ratios: in ♀, ant. I : II : III : IV = 1 : 1.8 : 2.9 : 5.4 and ant. : ceph. diag. = 1.6; in ♂, ant. I : II : III : IV = 1 : 1.9 : 3.3 : 6.4 and ant. : ceph. diag. = 2.1. Chaetotaxic variables of ♂ have not the same values between populations; absolute minimum and maximum as well as range of average are given. In both sexes, $m(ISH^*) = 0.58$. In ♀ : for *G*: $m = 90$ / min = 86 / max = 94 ; $m(RSh) = 0.40$. In ♂ : for *G*: $m = 100.5 - 104.9$ / min = 95 / max = 112 ; $m(RSh) = 0.34 - 0.36$.

Head. — Eyes: 8+8; eyepatch with two setae. Cephalic setae: mesochaetae. No ov. org. Labral formula: 6/5-5-4.

Legs. — Femur: cup present. Tibiotarsal generatrix Gp with two setae on fore-legs, and often one on midlegs. Several long macrochaetae on tibiotarsal outer side. Pretarsus characteristic of the genus.

Ventral tube. — Sacs warty from 2st st. on. Chaetotaxy: apical flaps with one pair of primary setae, corpus without seta.

Retinaculum. — At 1st st. rami tridentate, bidentate from 2nd. Chaetotaxy: on anterior lobe two setae appear at 3rd st. and one in ad.

Furcula — (DE)IVpi variable in some populations.

Small abd. — Made up of abd. V + abd. VI. Trichobothria: D and E. Male genital papilla with 12 setae. Female circumanal setae av1' and av1 shorter than the others. An. app. fairly long, flat, pointed and slightly serrated. Ratio an. app. : mucro = 0.68.

Deuterosminthurus maculatus sp. n.

(Figs 21-24; Table IV)

MATERIAL EXAMINED — FRANCE, dép. Aveyron, district Montrozier, Causse Comtal, road to Gages, alt. 620 m; collected with a net on *Juniperus communis* (AV2d). 23-V-1987. Syntypes: 7 juv. and 20 ad.; 5 juv., 3 ♀, and 2 ♂ mounted (LEITT).

Other material.— Same station. 17-IV-1987: 2 juv. and 1 ♀. 30-VII-1987: 1 juv (LEITT). — Same location; grass and small shrub at the edge of a grove of *Quercus pubescens*, with *Teucrium chamaedris*, *Hippocrepis comosa*, *Spiraea hypericifolia*, *Helianthemum canum*, *Ornithogalum umbellatum*, *Euphorbia dulcis*, and *Fumana procumbens*; collected with a net on unselected plants (AV2e). Several collections from 17-IV-1987 to 1-X-1987. In all 24 specimens; 4 juv., 2 ♀, and 1 ♂ mounted (LEITT). — Dép Aveyron, district Bessuéjols, Le Plateau de la Justice, alt. 450 m; meadow belonging to the phytosociological association of

Orchido-Brometum with some small trees (*Quercus pubescens*, *Pinus sylvestris*, *Juniperus communis*), and *Bromus erectus*, *Hippocrepis comosa*, *Globularia vulgaris*, *Eryngium campestre*, etc.; collected with a net on unselected plants (AV1a). 17-IV-1987: 1 ♀ mounted. 23-V-1987: 1 juv. (LEITT). — Dép. Aude, district Valmigère, road D54 between Valmigère and Arques, near Valmigère, alt. 680 m; moor with *Pteridium aquilinum*; collected with a net on this plant (AU11e). 8-VIII-1987: 33 specimens; 4 juv., 1 ♀, and 3 ♂ mounted (LEITT). — Dép. Haute-Garonne, district Roquefort-sur-Garonne, field between the roads D62 and N117, alt. 270 m; hedge with *Salix caprea*, *Cornus sanguinea*, *Rubus* sp., *Rosa* sp., *Cytisus scoparius*, *Quercus pubescens*, *Clematis vitalba*, etc.; collected with a net on the hedge (HG5b). 16-VI-1987: 116 specimens (12 specimens in alcohol in MHNG, 12 in MNHN, 12 in ZMA, other specimens in LEITT).

DESCRIPTION

Development. — Number of juv. st. = 3.

Size ad. — ♂: 0.5 - 0.6 mm; ♀: 0.65 - 0.9 mm.

Color (fig. 21). — Background white or very light yellow in female, yellow in male. Several brown patches arranged in a characteristic pattern. Spots of female forming a pair of laterodorsal stripes along the great abd. A mediodorsal band more or less pigmented with orange. The laterodorsal stripes are completely or partially connected by two cross flecks, one is near the halfway back, the other situated in the rear quarter. End of great abd. spotted with a transversally stretched out fleck which does not reach the laterodorsal stripes. Two oblong patches in a very lateral position. Expanse of brown pigment on small abd. varying between specimens. Expanse of dark pigment is lesser in males, lateral brown stripes being narrower and vanished forward about halfway the back. At this level, the cross fleck, present in females, is absent or very faded in males. Head colored with yellow excepted for a light area around the eyepatches. Eyepatches black. Color of antennae varying from yellow to brown, lighter on the three first segments than on the fourth. Legs light yellow; furcula white.

Great abd (fig. 24). — Back concave in posterior area. Trichobothria: A, B, and C in linear pattern. Dorsal setae: mesochaetae. Posterior cross row with always 4 setae.

Antennae. — Several setae transformed in acanthoids on ant. I and II in adult male. Antennal ratios: in ♀, ant. I : II : III : IV = 1 : 1.8 : 2.6 : 5.1 and ant. : ceph. diag. = 1.6; in ♂, ant. I : II : III : IV = 1 : 1.8 : 2.8 : 5.5 and ant. : ceph. diag. = 2.0. Chaetotaxic variables, in both sexes: $m(ISH^*) = 0.67$; in ♀: for G : $m = 97.0$ / $min = 94$ / $max = 101$; $m(RSh) = 0.41$; in ♂: for G : $m = 104.2$ / $min = 102$ / $max = 111$; $m(RSh) = 0.38$.

Head. — Eyes: 8+8; eyepatch with two setae. Cephalic setae: mesochaetae, some facial setae being longer in male than in female. 1+1 ov. org. in the back-ventral area (it remains the ventral pair). Labral formula: 6/5-5-4.

Legs. — Femur: cup present, as well as the seta (FE3)pe1. Tibiotarsal generatrix Gp with two setae on forelegs, and two on midlegs. Pretarsus characteristic of the genus.

Ventral tube. — Sacs warty from 2st st. on. Chaetotaxy: apical flaps with one pair of primary setae, corpus without seta.

Retinaculum. — At 1st st. rami tridentate, bidentate from 2nd. Chaetotaxy: on anterior lobe two setae appear at 3rd st. and one in ad.

Furcula. — (DE)IVpi often absent.

Small abd. (figs 22-24). — Made up of abd. V + abd. VI. Trichobothria: D and E. Male genital papilla with 12-13 setae. Female circumanal setae with about the same length. An. app. flat, pointed and serrated. Ratio an. app. : mucro = 0.49.

DISCUSSION

D. pallipes and *D. maculatus* sp. n. can be distinguished from the other species of *Deuterosminthurus* by the seta (FE3)pe1 present from the 1st st. on, the male acanthoids on ant. I and II (see ELLIS, 1974, fig. 7b p. 135), and 1+1 ov. org. behind the head. The color pattern is very characteristic and invariable in *maculatus*, whereas *pallipes* displays a wide range of colors without specific pattern. Two other characters can be used: *pallipes* has 4 to 6 long setae on the last cross row of great abd., and *maculatus*, as the other species of *Deuterosminthurus* I have observed, always bears 4 setae, and the antennal acanthoids of *maculatus* are thicker than in *pallipes*.

Etymology: The name *maculatus* from Latin *macula* = mark, spot.

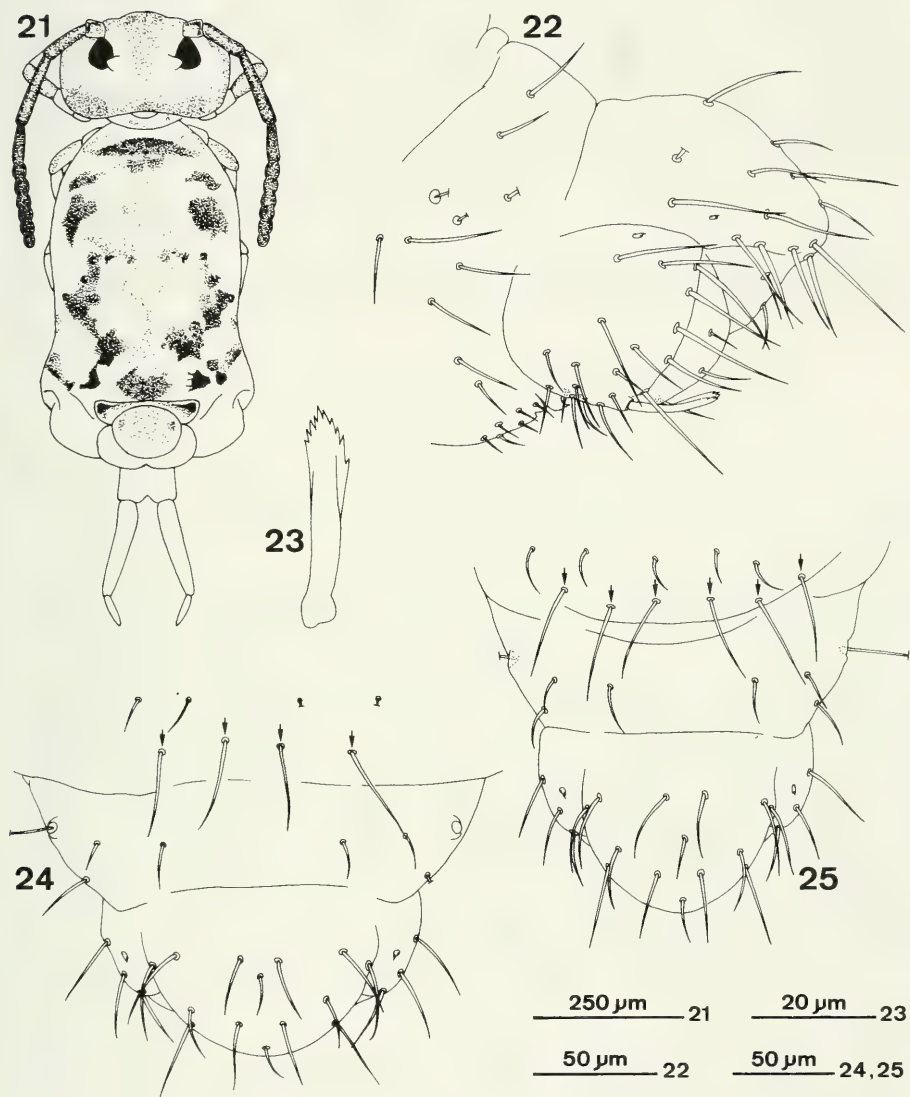
Deuterosminthurus pallipes (Bourlet, 1843)

(Fig. 25)

MATERIAL EXAMINED — FRANCE, dép. Aveyron, district Montrozier, Causse Comtal, road to Gages, alt. 620 m; grass on limestone with *Bromus erectus*, *Kaëleria valesiaca*, *Festuca* gr. *ovina*, *Coronilla minima*, *Hippocrepis comosa*, *Lotus corniculatus*, *Anthyllis vulneraria*, *Carduncellus mitissimus*, *Eryngium campestre*, *Teucrium chamaedrys*, etc.; collected with a net on unselected plants (AV2a). Several collections from 17-IV-1987 to 11-IX-1987. In all 17 juv. and 11 ad.; 6 ad. and all juv. mounted (LEITT). — Same location; doline with *Molinia caerulea*, *Avena pratensis*, *Eryngium campestre*, *Carduncellus mitissimus*, *Lathyrus pratensis*, *Vicia peregrina*, and some specimens of *Prunus spinosa*; collected with a net on unselected plants (station AV2b). Several collections from 17-IV-1987 to 1-X-1987. In all 123 specimens; 32 juv. and 9 ad. mounted (LEITT). — Dép. Aveyron, district Sébazac-Concourès, Causse Comtal, road D581 between Lioujas and Concourès, alt. 600 m; collected with a net on *Spiraea hypericifolia* (AV7d). 21-VI-1986: many specimens; 4 juv. mounted (LEITT). — Dép. Pyrénées-Orientales, district Lesquerde, road D619 between Saint-Paul-de-Fenouillet and Ansignan, about 3 km from Saint-Paul-de-Fenouillet, alt. 350 m; scrub with *Quercus ilex*, *Bupleurum fruticosum*, *Quercus coccifera*, etc.; collected with a net on unselected plants (PO15a). 24-VI-1987: 142 specimens; 8 juv. and 7 ad. mounted (LEITT).

DESCRIPTION

Concerning the appendicular chaetotaxic table, refer to *D. maculatus* (Table IV), with the following differences:



FIGS 21-25

Figs 21-24: *Deuterosminthurus maculatus* sp. n. ♀; 21: habitus; 22: small abd. in lateral view; 23: right an. app. in ventral view; 24: small abd. and posterior area of great abd. in dorsal view, arrows point setae of the most posterior row of great abd. Fig. 25: *Deuterosminthurus pallipes* ♀, small abd. and posterior area of great abd. in dorsal view, arrows point setae of the most posterior row of great abd.

Antennae. Acanthoids of male are a little less stout than in *maculatus*, and (AD)Ap cannot be termed an acanthoid. I have noted some differences between populations. (AD)pe+1, depending on populations, appears or not at 3rd st. (oc varying from 0 to 1) — Occurrences of H setae on M & B: for Heae 1-1-1-1-0/0, and fluctuate for Hppe from 1-1-1-1-0/0 to 1-1-1-1-0.8/0. Consequently, $m(h^*)$ varies from 4.0 to 4.4. — Chaetotaxic variables in ♀: $n80\%(BM) = 12-15 / 14-17$; $n80\%(B) = 25-28 / 27-30$; $n80\%(G) = 90-93 / 92-95$. In ♂: $n80\%(BM) = 19-24 / 22-30$; $n80\%(B) = 32-37 / 35-43$; $n80\%(G) = 97-102 / 100-108$. BA complete whorl in both sexes.

Furcula. The primary seta (DE)IVpi is seldom present, its occurrence varying from 0 to 0.2.

Development. — Number of juv. st. = 3.

Size ad. — ♂: 0.45 - 0.55 mm; ♀: 0.6 - 0.75 mm.

Color. — Very variable between populations, from light yellow to very dark purple. Males are generally more colored than females. Color depends on climatic zones in which populations live. Males of the Mediterranean area vary from orange flecked to entirely dark red. Females are generally yellow, with sometimes orange or ochre spots. In Atlantic area, two different patterns are mixed, most of specimens are yellow, some others, males and females, are dark purple (this form corresponds to the typical color of pallipes). In mountains, specimens living on *Rhododendron ferrugineum* are wine-red (only one yellow female was observed in a collection of more 100 specimens). In other areas, specimens are yellow (this form was described as *repandus*). In Mediterranean populations, females are colored with orange or ochre shades as in *D. maculatus*, but the pigment is far more diffuse than in *maculatus*. In addition, color widely varies between specimens, and in these populations, entirely red males are present, so that one cannot confuse the species. Head more or less colored, depending on the expanse of pigment on the body; surround of eyepatches often remains light as in *maculatus*. Eyepatches black, antennae with pigment varying from yellow to brown, legs light yellow, furcula white.

Great abd. (fig. 25). — Back concave in posterior area. Trichobothria: A, B, and C in linear pattern. Dorsal setae: mesochaetae. Posterior cross row with 4 to 6 setae.

Antennae. — Several setae transformed in acanthoids on ant. I and II in adult male. Antennal ratios: in ♀, ant. I : II : III : IV = 1 : 1.8 : 2.7 : 5.2 and ant. : cephalic diag. = 1.6; in ♂, ant. I : II : III : IV = 1 : 1.7 : 2.7 : 5.4 and ant. : cephalic diag. = 1.9. Chaetotaxic variables with some differences between populations. Absolute minimum, maximum, and range of average are given. In both sexes: $m(ISH^*) = 0.67 - 0.73$. In ♀: for *G*: $m = 91.8 - 93.1 / \min = 90 / \max = 96$; $m(RSh) = 0.44 - 0.46$; in ♂: for *G*: $m = 99.9 - 104.3 / \min = 97 / \max = 109$; $m(RSh) = 0.40 - 0.41$.

Head. — Eyes: 8+8; eyepatch with two setae. Cephalic setae: mesochaetae, some facial setae being longer in male than in female. 1+1 ov. org. in the back-ventral area (it remains the ventral pair). Labral formula: 6/5-5-4.

Legs. — Femur: cup present, as well as the seta (FE3)pe1. Tibiotarsal generatrix Gp with two setae on forelegs, and two on midlegs. Pretarsus characteristic of the genus.

Ventral tube. — Sacs warty from 2st st. on. Chaetotaxy: apical flaps with one pair of primary setae, corpus without seta.

Retinaculum. — At 1st st. rami tridentate, bidentate from 2nd. Chaetotaxy: on anterior lobe two setae appear at 3rd st. and one in ad.

Furcula. — In most cases, (DE)IVpi absent.

Small abd. (fig. 25). — Made up of abd. V + abd. VI. Trichobothria: D and E. Male genital papilla with 12-13 setae. Female circumanal setae with about the same length. An. app. flat, pointed and serrated. Ratio an. app. : mucro = 0.52.

DISTINCTION OF THE EUROPEAN SPECIES OF *Deuterosminthurus*

A key to the European species of *Deuterosminthurus* is provided, that includes the studied species as well as *D. pandayi* Ellis, 1974 and *D. mediterraneus* Ellis, 1974, stat. nov. I recall that *D. cruciata* Haybach, 1972 should be taken out from *Deuterosminthurus* and placed in *Cassagnaudiella* (ELLIS 1975; NAYROLLES 1995). *D. quadrangulata* (Loksa & Bogojevi³, 1970) was described from only one female. The description was insufficient, and this species is not included in the key.

In their description of *D. quadrangulata*, LOKSA & BOGOJEVI³ (1970) noted: "Die neue Art steht der Art *repanda* (Ågren, 1903) am nächsten. Unterscheidet sich von dieser durch das Muster, durch die Zahl der zirkumanalen Borsten und durch die Anordnung dieser." However, the figure of small abd. given by LOKSA & BOGOJEVI³ (*ibid.*, fig. 63, p. 141) does not show any difference from *pallipes*. The claw of *quadrangulata* was described as untoothed; on the contrary, a tooth is generally present on the inner side of the claw of *pallipes*. Nevertheless, this character, difficult to observe and sometimes variable, has long been given an excessive importance, and I consider it to be irrelevant for distinguishing species. The color does not make up a good character any more. It is variable, without a defined pattern in *pallipes*; on the other hand, *quadrangulata* is not really different from certain colored specimens of *pallipes*. Consequently, the distinction between *quadrangulata* and *pallipes* may be questioned. However, LOKSA & BOGOJEVI³ described a retinaculum with two setae, and all *Deuterosminthurus* species I have observed have three setae in adult. Do the two *quadrangulata*'s setae come from a mistake in observation, an aberrant specimen, or an actual species character? Only new collections in the location in which *quadrangulata* was found (Deliblat, Yugoslavia) and new observations may give an answer.

KEY TO EUROPEAN SPECIES OF *Deuterosminthurus*

- 1 - three thick setae (IIa, IIIa, and IIai) on anterior dental side *pandayi*
- no thick setae on the dens 2

- 2 - macrochaetae on outer side of tibiotarsi 3
- tibiotarsi without macrochaetae 4
- 3 - posterior margin of the male upper anal flap with 1+1 acanthoids . . *sulphureus*
- male upper anal flap without acanthoid *mediterraneus*
- 4 - (FE3)p1 present, 1+1 ov. org. behind head, several acanthoids on male ant. I and II 5
- (FE3)p1 absent, no ov. org. behind head, no acanthoid on male ant. I and II 6
- 5 - brown spots forming a characteristic pattern, 4 long setae on the most posterior row of great abd. *maculatus* sp. n.
- variable color without a defined pattern, 4 to 6 long setae on the most posterior row of great abd. *pallipes*
- 6 - male great abd. with acanthoids *pleuracanthus* sp. n.
- no acanthoid on male great abd. 7
- 7 - back of great abd. with often two black patches, ant. IV with 9 setae in the set Heae + Hppe of M section. *bicinctus*
- back of great abd. unstained, ant. IV with 7 setae in the set Heae + Hppe of M section *flavus*

For the studied species, we can distinguish, on the one hand, those (*maculatus* and *pallipes*) displaying the seta (FE3)pel from the 1st instar on, acanthoids on ant. I and II in males, and 1+1 ov. org. on the back-ventral area of head, and on the other hand, those (*sulphureus*, *pleuracanthus*, *bicinctus*, and *flavus*) without the seta (FE3)pel, nor male special shaped setae, nor cephalic ov. org. Concerning *pandayi* and *mediterraneus*, we know from ELLIS (1974) that they have no male antennal acanthoid, it will be then of interest to determine whether the seta (FE3)pel and ov. org. behind the head are present or absent.

REFERENCES

- BETSCH, J. M. 1974. Etude des Collemboles de Madagascar. II. - Principaux cadres génériques des Symphypléones de l'étage montagnard. *Bulletin du Muséum national d'Histoire naturelle, Paris*, 3° série, 219, Zoologie, 147: 529-569.
- BETSCH, J. M. 1980. Eléments pour une monographie des Collemboles Symphypléones (Hexapodes, Aptérygotes). *Mémoires du Muséum national d'Histoire naturelle, Paris*, A, 116: 1-227.
- BETSCH, J. M. & Z. MASSOUD. 1970. Etude sur les Insectes Collemboles. I. Systématique, ultrastructure externe et écologie du genre *Jeannenotia* Stach, 1956 (Symphypléones, Sminthuridae n. comb.). Description de deux Collemboles nouveaux (*Proisotoma* et *Sminthurides*). *Revue d'Écologie et de Biologie du Sol* 7 (2): 153-225.
- BETSCH, J. M. & A. WALLER. 1989. L'armement en trichobothries des Collemboles Symphypléones. Recherche de schémas chétotaxiques, pp. 15-31. In *Proceedings of the Third International Seminar on Apterygota* (R. Dallai ed.). *Università di Siena, Italy*.

- BETSCH, J. M. & A. WALLER. 1994. Chaetotaxic nomenclature of the head, thorax, and abdomen in Symphypleona (Insecta, Collembola). *Acta zoologica Fennica*, 195: 5-12.
- BRETFELD, G. 1986. A new chaetotaxic character in some *Heterosminthurus* species (Insecta, Collembola, Symphypleona), pp. 19-22. In *Proceedings of the Second International Seminar on Apterygota* (R. Dallai ed.), *Università di Siena, Italy*.
- BRETFELD, G. 1988. Zwei neue Farbformen von *Heterosminthurus insignis* (Reuter, 1876) und Unterscheidungsmerkmale zu *Heterosminthurus novemlineatus* (Tullberg, 1871) (Insecta, Collembola, Symphypleona). *Abhandlungen und Berichte des Naturkundemuseums Görlitz* 62: 1-8.
- BRETFELD, G. 1990. Chaetotaxy of four Species of the Genera *Heterosminthurus*, *Bourletiella*, *Deuterosminthurus* and *Prorastriopes* (Insecta, Collembola, Symphypleona). *Zoologische Jahrbücher. Abteilung für Systematik, Ökologie und Geographie der Tiere* 117: 441-489.
- ELLIS, W. N. 1974. The spring fauna of Collembola (Insecta) from Rhodos, with descriptions of some new taxa. *Beaufortia*, 22 (292): 105-152.
- ELLIS, W. N. 1975. On *Bourletiella* (*Cassagnaudiella*) *pruinosa* (Tullberg, 1871) and its allies (Collembola: Sminthuridae). *Bulletin Zoologisch Museum, Universiteit van Amsterdam* 4: 69-81.
- ELLIS, W. N. 1978. Pollen feeding of *Deuterosminthurus repandus* (Ågren) in the High Pyrenees, and some systematic notes (Collembola: Sminthuridae). *Entomologische Berichten* 38: 61-63.
- LOKSA, I. & J. BOGOJEVIĆ. 1970. Einige interessante Collembolen-Arten aus der Sandwüste von Deliblat, Jugoslawien. *Opuscula Zoologica (Budapest)*, 10 (1): 125-142.
- NAYROLLES, P. 1991a. La chétotaxie antennaire des Collembolles Symphypléones. *Travaux du Laboratoire d'Écobiologie des Arthropodes édaphiques, Toulouse*, 6 (3): 1-94.
- NAYROLLES, P. 1991b. Contribution à l'étude ontophylogénétique et écologique des Collembolles Symphypléones épigés. *Thèse de l'Université P. Sabatier, Toulouse*, 329 pp.
- NAYROLLES, P. 1993a. A standardized description of European Sminthuridae (Collembola, Symphypleona), 1: genera *Lipothrix*, *Gisinurus*, and *Caprainea*. *Bijdragen tot de Dierkunde* 63 (1): 43-60.
- NAYROLLES, P. 1993b. Contribution to the knowledge of European Bourletiellidae (Collembola, Symphypleona). I. On a standard of description and on the genus *Fasciosminthurus* Gisin, 1960, sensu Bretfeld, 1992. *Revue suisse de Zoologie*, 100 (3): 655-673.
- NAYROLLES, P. 1993c. La biométrie des caractères discontinus d'après le revêtement appendiculaire des Collembolles Symphypléones. I. Sur quelques concepts nouveaux dans l'analyse numérique de la chétotaxie. *Bulletin du Muséum national d'Histoire naturelle, Paris*. 4e sér., 15: 79-93.
- NAYROLLES, P. 1994. Contribution to the knowledge of European Bourletiellidae (Collembola, Symphypleona). II. Redescription of three species and description of three new species of *Fasciosminthurus*. *Revue suisse de Zoologie*, 101 (2): 315-333.
- NAYROLLES, P. 1995. Taxonomy of European species of *Cassagnaudiella* and *Bourletiella* (Collembola, Symphypleona, Bourletiellidae). *Zoologica Scripta*, 24 (1): 43-60.
- RICHARDS, W. R. 1968. Generic classification, evolution and biogeography of the Sminthuridae of the world (Collembola). *Memoirs of the Entomological Society of Canada*, 53: 1-54.